

ATTACHMENT B

Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application.

1-5. (canceled)

6. (currently amended) A method of operating a 4-stroke reciprocating engine wherein the engine is operating between a minimum speed of rotation N_{min} and a maximum speed N_{max} and comprises:

a turbocharging unit comprising:

- a compressor which supplies an intake manifold of the engine with compressed air via a cooler;
- a turbine which is supplied with a hot exhaust gas by an exhaust manifold of the engine at an exhaust temperature, the turbine defining an exhaust outlet section S_d offered to said hot exhaust gas; and

an EGR bypass provided between the intake manifold and the exhaust manifold which EGR bypass is dimensioned to transfer a flow of gas between the intake manifold and the outlet manifold without substantial loss of pressure,

such that a turbine inlet pressure substantially equal to a compressor discharge pressure;

such that, at constant air temperature and with a constant value of the exhaust outlet section S_d , the turbocharging unit delivers a substantially constant volume of cooled air V_c when the compressor discharge pressure varies, the constant volume of cooled air V_c being substantially proportional to the exhaust outlet section S_d offered to the hot exhaust gas,

wherein the exhaust outlet section S_d is selected such that

at a turbocharging adaptation speed N_a , the volume drawn in by the engine is equal to the constant volume V_c ,

below the turbocharging adaptation speed N_a , the volume drawn in by the engine is less than the constant volume of cooled air V_c , and a flow of the cooled air is deflected toward the turbocharging unit through the EGR bypass, and

above the turbocharging adaptation speed N_a and including the maximum speed N_{max} , the volume drawn in by the engine is more than the constant volume of cooled air V_c , and a flow of exhaust gas is drawn in by the engine through the EGR bypass,

wherein the EGR bypass has a gas cooler adjustable to control the temperature of the transferred flow of the hot exhaust gas, and

wherein the method of operating includes controlling the EGR bypass temperature to create a desired excess of air for combustion in the engine; and

wherein the exhaust outlet section S_d is selectively variable and is controlled:

- at full load, to maintain a parameter at a limiting desired value thereof; and
- at partial load, to optimize depollution and/or performance according to a map stored in an engine control computer.

7. (previously presented) A method of operating a 4-stroke reciprocating engine wherein the engine is operating between a minimum speed of rotation N_{min} and a maximum speed N_{max} and comprises:

a turbocharging unit comprising:

- a compressor which supplies an intake manifold of the engine with compressed air via a cooler;
- a turbine which is supplied with a hot exhaust gas by an exhaust manifold of the engine at an exhaust temperature, the turbine defining an exhaust outlet section S_d offered to said hot exhaust gas; and

an EGR bypass provided between the intake manifold and the exhaust manifold which EGR bypass is dimensioned to transfer a flow of gas between the intake manifold and the outlet manifold without substantial loss of pressure,

such that a turbine inlet pressure is maintained substantially equal to a compressor discharge pressure;

such that, at constant air temperature and with a constant value of the exhaust outlet section S_d , the turbocharging unit delivers a substantially constant volume of cooled air V_c when the compressor discharge pressure varies, the constant volume of cooled air V_c being substantially proportional to the exhaust outlet section S_d offered to the hot exhaust gas,

wherein the exhaust outlet section S_d is selected such that,

at a turbocharging adaptation speed N_a , the volume drawn in by the engine is equal to the constant volume V_c ,

below the turbocharging adaptation speed N_a , the volume drawn in by the engine is less than the constant volume of cooled air V_c , and a flow of the cooled air is deflected toward the turbocharging unit through the EGR bypass, and

above the turbocharging adaptation speed N_a and including the maximum speed N_{max} , the volume drawn in by the engine is more than the constant volume of cooled air V_c , and a flow of exhaust gas is drawn in by the engine through the EGR bypass, and

wherein the EGR bypass has a gas cooler adjustable to control the temperature of the transferred flow of the hot exhaust gas; and

wherein the method of operating includes controlling the EGR bypass temperature so that a mass of the transferred hot exhaust gas remains substantially equal to a mass of the fresh air up to the speed at which this temperature returns to the exhaust temperature, the mass of the transferred hot exhaust gas becoming greater than the mass of the fresh air above this speed.

8. (currently amended) A 4-stroke reciprocating engine ~~as claimed in Claim 5, operating between a minimum speed of rotation N_{min} and a maximum speed N_{max} comprising:~~

a turbocharging unit comprising:

- a compressor which supplies an intake manifold of the engine with compressed air via a cooler;
- a turbine which is supplied with a hot exhaust gas by an exhaust manifold of the engine at an exhaust temperature, the turbine defining an exhaust outlet section S_d offered to said hot exhaust gas; and

an EGR bypass provided between the intake manifold and the exhaust manifold which EGR bypass is dimensioned to transfer a flow of gas between the intake manifold and the outlet manifold without substantial loss of pressure,

such that a turbine inlet pressure is maintained substantially equal to a compressor discharge pressure,

such that, at constant air temperature and with a constant value of the exhaust outlet section S_d , the turbocharging unit delivers a substantially constant volume of cooled air V_c when the compressor discharge pressure varies, the constant volume of cooled air V_c being substantially proportional to the exhaust outlet section S_d offered to the hot exhaust gas,

wherein the exhaust outlet section S_d is selected such that

at a turbocharging adaptation speed N_a , the volume drawn in by the engine is equal to the constant volume V_c ,

below the turbocharging adaptation speed N_a , the volume drawn in by the engine is less than the constant volume of cooled air V_c , and a flow of the cooled air is deflected toward the turbocharging unit through the EGR bypass, and

above the turbocharging adaptation speed N_a and including the maximum speed N_{max} , the volume drawn in by the engine is more than the constant volume of cooled air V_c , and a flow of exhaust gas is drawn in by the engine through the EGR bypass,

wherein the EGR bypass has a gas cooler adjustable to control the temperature of the transferred flow of the hot exhaust gas,

wherein the adjustment of the temperature is effected by controlling a bypass of the cooler, and

wherein the gas cooler is totally bypassed when the engine does not deliver propulsive power.

9. (currently amended) A 4-stroke reciprocating engine ~~as claimed in Claim 5,~~ operating between a minimum speed of rotation N_{min} and a maximum speed N_{max} comprising:

a turbocharging unit comprising:

- a compressor which supplies an intake manifold of the engine with compressed air via a cooler;
- a turbine which is supplied with a hot exhaust gas by an exhaust manifold of the engine at an exhaust temperature, the turbine defining an exhaust outlet section S_d offered to said hot exhaust gas; and

an EGR bypass provided between the intake manifold and the exhaust manifold which EGR bypass is dimensioned to transfer a flow of gas between the intake manifold and the outlet manifold without substantial loss of pressure,

such that a turbine inlet pressure is maintained substantially equal to a compressor discharge pressure,

such that, at constant air temperature and with a constant value of the exhaust outlet section S_d , the turbocharging unit delivers a substantially constant volume of cooled air V_c when the compressor discharge pressure varies, the constant volume of cooled air V_c being substantially proportional to the exhaust outlet section S_d offered to the hot exhaust gas,

wherein the exhaust outlet section S_d is selected such that

at a turbocharging adaptation speed N_a , the volume drawn in by the engine is equal to the constant volume V_c ,

below the turbocharging adaptation speed N_a , the volume drawn in by the engine is less than the constant volume of cooled air V_c , and a flow of the cooled air is deflected toward the turbocharging unit through the EGR bypass, and

above the turbocharging adaptation speed N_a and including the maximum speed N_{max} , the volume drawn in by the engine is more than the constant volume of cooled air V_c , and a flow of exhaust gas is drawn in by the engine through the EGR bypass,

wherein the EGR bypass has a gas cooler adjustable to control the temperature of the transferred flow of the hot exhaust gas,

wherein the adjustment of the temperature is effected by controlling a bypass of the cooler; and

wherein for cold starting and operating at idling speed, the exhaust outlet section S_d and/or a timing of engine valves is adjusted so that the excess of combustion air is minimal for a desired level of depollution.

10. (canceled)

11. (currently amended) A 4-stroke reciprocating engine as claimed in Claim 5, operating between a minimum speed of rotation N_{min} and a maximum speed N_{max} comprising:

a turbocharging unit comprising:

- a compressor which supplies an intake manifold of the engine with compressed air via a cooler;
- a turbine which is supplied with a hot exhaust gas by an exhaust manifold of the engine at an exhaust temperature, the turbine defining an exhaust outlet section S_d offered to said hot exhaust gas; and

an EGR bypass provided between the intake manifold and the exhaust manifold which EGR bypass is dimensioned to transfer a flow of gas between the intake manifold and the outlet manifold without substantial loss of pressure,

such that a turbine inlet pressure is maintained substantially equal to a compressor discharge pressure,

such that, at constant air temperature and with a constant value of the exhaust outlet section S_d , the turbocharging unit delivers a substantially constant volume of cooled air V_c when the compressor discharge pressure varies, the constant volume of cooled air V_c being substantially proportional to the exhaust outlet section S_d offered to the hot exhaust gas,

wherein the exhaust outlet section S_d is selected such that

at a turbocharging adaptation speed N_a , the volume drawn in by the engine is equal to the constant volume V_c ,

below the turbocharging adaptation speed N_a , the volume drawn in by the engine is less than the constant volume of cooled air V_c , and a flow of the cooled air is deflected toward the turbocharging unit through the EGR bypass, and

above the turbocharging adaptation speed N_a and including the maximum speed N_{max} , the volume drawn in by the engine is more than the constant volume of cooled air V_c , and a flow of exhaust gas is drawn in by the engine through the EGR bypass,

wherein the EGR bypass has a gas cooler adjustable to control the temperature of the transferred flow of the hot exhaust gas,

wherein the adjustment of the temperature is effected by controlling a bypass of the cooler,

wherein the adaptation speed N_a is substantially equal to $N_{min}/2$ so that the volume of the transferred flow of the hot exhaust gas is at least equal to that of the fresh air, and

wherein the minimum temperature of the transferred flow of the hot exhaust gas is close to the temperature of the fresh air so that a mass of the transferred flow of the hot exhaust gas is at least equal to that of the fresh air at the minimum speed used N_{min} in order to depollute down to the minimum speed N_{min} .

12. (previously presented) A 4-stroke reciprocating engine operating between a minimum speed of rotation N_{min} and a maximum speed N_{max} comprising:

a turbocharging unit comprising:

- a compressor which supplies an intake manifold of the engine with compressed air via a cooler;
- a turbine which is supplied with a hot exhaust gas by an exhaust manifold of the engine at an exhaust temperature, the turbine defining an exhaust outlet section S_d offered to said hot exhaust gas; and

an EGR bypass provided between the intake manifold and the exhaust manifold which EGR bypass is dimensioned to transfer a flow of gas between the intake manifold and the outlet manifold without substantial loss of pressure,

such that a turbine inlet pressure is maintained substantially equal to a compressor discharge pressure;

such that, at constant air temperature and with a constant value of the exhaust outlet section S_d , the turbocharging unit delivers a substantially constant volume of cooled air V_c when the compressor discharge pressure varies, the constant volume of cooled air V_c being substantially proportional to the exhaust outlet section S_d offered to the hot exhaust gas,

wherein the exhaust outlet section S_d is selected such that,

at a turbocharging adaptation speed N_a , the volume drawn in by the engine is equal to the constant volume V_c ,

below the turbocharging adaptation speed N_a , the volume drawn in by the engine is less than the constant volume of cooled air V_c , and a flow of the cooled air is deflected toward the turbocharging unit through the EGR bypass, and

above the turbocharging adaptation speed N_a and including the maximum speed N_{max} , the volume drawn in by the engine is more than the constant volume of cooled air V_c , and a flow of exhaust gas is drawn in by the engine through the EGR bypass,

wherein the turbocharging unit has a low-pressure LP turbocharger having an LP turbine and an LP compressor, and a high-pressure HP turbocharger having an HP turbine and an HP compressor, the LP and HP compressors working in series,

wherein the exhaust outlet section S_d offered to the hot exhaust gases is adjustable between a minimum $S_{d \min}$ and a maximum $S_{d \max}$ by one or a combination of the following:

- adjustment of a variable section of a gas distributor of the turbines,
- opening of a bypass between an inlet and an outlet of the turbines, and
- passage from a series configuration to a parallel configuration of the turbines,

the turbocharging adaptation speed N_a thus being adjustable, in a continuous or discontinuous manner, between two values $N_{a \min}$ and $N_{a \max}$.

13. (previously presented) A 4-stroke reciprocating engine as claimed in Claim 12, wherein the minimum exhaust outlet section $S_{d \min}$ offered to the gases is formed by the two turbines mounted in series, with variable distributors being at maximum closure.

14. (previously presented) A 4-stroke reciprocating engine as claimed in Claim 12, wherein the minimum exhaust outlet section $S_{d \min}$ offered to the hot exhaust gas is formed by the two turbines with fixed distributors mounted in series, waste gates of the turbines being in a closed position.

15. (previously presented) A 4-stroke reciprocating engine as claimed in Claim 12, wherein the maximum exhaust outlet section $S_{d \max}$ offered to the gases is formed by the two turbines which have fixed distributors mounted in parallel, and

wherein, in order to pass the turbines from the series configuration to the parallel configuration, the following manoeuvres are carried out successively:

- progressive partial opening of an HP waste gate between the inlet and the outlet of the HP turbine,

- progressive and simultaneous partial opening of the HP waste gate and an LP waste gate between the inlet and the outlet of the LP turbine, and
- simultaneously and rapidly: total opening of the HP waste gate, total closure of the LP waste gate, and putting the outlet of the HP turbine into communication with the outlet of the LP turbine.

16. (previously presented) A 4-stroke reciprocating engine as claimed in Claim 12, wherein the maximum outlet section S_d max offered to the gases is formed by the LP turbine with fixed distributor and the HP turbine with variable distributor mounted in parallel, an HP variable distributor being fully open, and wherein, in order to pass the turbines from the series configuration to the parallel configuration, the following manoeuvres are carried out successively:

- progressive opening of a distributor of the HP turbine,
- progressive partial opening of an LP waste gate,
- simultaneously and rapidly: total opening of the LP waste gate and putting the outlet of the HP turbine into communication with the outlet of the LP turbine.

17. (previously presented) A 4-stroke reciprocating engine as claimed in claim 12, wherein the EGR bypass has an EGR valve to increase the turbine inlet pressure above the compressor discharge pressure; and wherein the method of operating includes, in order to limit a frequency of changing a configuration, maintaining the turbines in series configuration for a type of driving which implements a limited power range, and crossing power thresholds corresponding to this configuration for manoeuvres of short duration by closure of the EGR valve.

18. (previously presented) A 4-stroke reciprocating engine as claimed in claim 15, wherein, in order to limit a frequency of changing a configuration, the turbines are maintained in a series configuration for a type of driving which implements a limited power range, and crossing power thresholds corresponding to this configuration for manoeuvres of short duration by opening of one or both of the waste gates.

19. (previously presented) A method of operating a 4-stroke reciprocating engine as claimed in Claim 18,

wherein, the EGR bypass has an EGR valve to increase the turbine inlet pressure above the compressor discharge pressure, and

the method includes crossing of the power thresholds by closure of the EGR valve and by opening of one or both of the waste gate.

20. (previously presented) A 4-stroke reciprocating engine as claimed in Claim 15, wherein the LP waste gate has a second seat in order simultaneously to effect a closure of the LP turbine inlet/outlet bypass and putting the HP turbine outlet into communication with the LP turbine outlet.

21. (previously presented) A 4-stroke reciprocating engine as claimed in Claim 15, wherein the two waste gates are concentric and have stops such that simultaneous movements thereof are actuated by one and communicated to the other by the stops.

22. (previously presented) A 4-stroke reciprocating engine as claimed in Claim 13 wherein the maximum exhaust outlet section $S_d \max$ is formed by two turbines with fully open variable distributors mounted in series, and wherein the distributors are opened simultaneously in order to maintain the intake pressure at a maximum desired value thereof on a full load curve.

23. (previously presented) A 4-stroke reciprocating engine as claimed in Claim 14,

wherein a timing of engine valves is controlled to displace a closure of an associated cylinder between the vicinity of the BDC and the mid-stroke of an associated piston,

wherein the maximum exhaust outlet section S_d is formed by the HP turbine in series configuration; and

wherein the turbines are dimensioned to permit the compressors thereof to reach maximum pressure ratios thereof simultaneously.

24. (previously presented) A method of operating a 4-stroke reciprocating engine as claimed in Claim 23, wherein a full load curve as a function of the speed is operated as follows:

from N_{min} to $2 N_{min}$, an intake closure FA passes from the BDC to approximately 90 degrees of a crankshaft after the BDC to maintain a cycle pressure below a desired value thereof, and

a distributor or an HP waste gate is closed;

from $2 N_{min}$ to approximately $3 N_{min}$, the HP distributor or the HP waste gate is open to maintain an intake pressure at a maximum desired value thereof, and

the intake closure FA is maintained at 90 degrees of the crankshaft after the BDC; and

from $3 N_{min}$ to N_{max} , a global flow rate of fuel is kept constant to maintain the intake pressure at a limiting value thereof, and

at partial load, a timing of intake closure FA is controlled according to a map stored in an engine control computer.

25. - 29. (canceled)

30. (previously presented) A method of operating a 4-stroke reciprocating engine as claimed in Claim 7, wherein the exhaust outlet section S_d is selectively variable and is controlled:

at full load, to maintain a parameter at a limiting desired value thereof; and

at partial load, to optimize depollution and/or performance according to a map stored in an engine control computer.

31. (previously presented) A method of operating a 4-stroke reciprocating engine as claimed in Claim 8, wherein the exhaust outlet section S_d is selectively variable and is controlled:

at full load, to maintain a parameter at a limiting desired value thereof; and

at partial load, to optimize depollution and/or performance according to a map stored in an engine control computer.

32. (previously presented) A method of operating a 4-stroke reciprocating engine as claimed in Claim 9, wherein the exhaust outlet section S_d is selectively variable and is controlled:

at full load, to maintain a parameter at a limiting desired value thereof; and
at partial load, to optimize depollution and/or performance according to a map stored in
an engine control computer.

33. (previously presented) A method of operating a 4-stroke reciprocating engine as claimed in
Claim 17, wherein the exhaust outlet section Sd is selectively variable and is controlled:

at full load, to maintain a parameter at a limiting desired value thereof; and
at partial load, to optimize depollution and/or performance according to a map stored in
an engine control computer.

34. (previously presented) A method of operating a 4-stroke reciprocating engine as claimed in
Claim 18, wherein the exhaust outlet section Sd is selectively variable and is controlled:

at full load, to maintain a parameter at a limiting desired value thereof; and
at partial load, to optimize depollution and/or performance according to a map stored in
an engine control computer.

35. (previously presented) A method of operating a 4-stroke reciprocating engine as claimed in
Claim 19, wherein the exhaust outlet section Sd is selectively variable and is controlled:

at full load, to maintain a parameter at a limiting desired value thereof; and
at partial load, to optimize depollution and/or performance according to a map stored in
an engine control computer.

36. (previously presented) A method of operating a 4-stroke reciprocating engine as claimed in
Claim 24, wherein the exhaust outlet section Sd is selectively variable and is controlled:

at full load, to maintain a parameter at a limiting desired value thereof; and
at partial load, to optimize depollution and/or performance according to a map stored in
an engine control computer.

37. - 51. (canceled)

52. (previously presented) A 4-stroke reciprocating engine as in claim 15, wherein the section of the HP waste gate fully opened is smaller than the section of the LP turbine to increase the gas flow through the HP turbine in the parallel configuration.

53.- 62. (canceled)